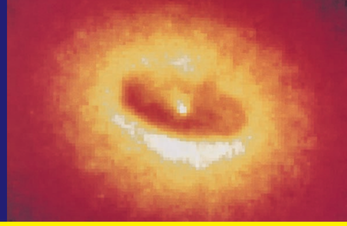
UNIT 3 Review



Knowledge/Understanding

Multiple Choice

In your notebook, choose the most correct answer for each of the following questions. Outline your reasons for your choice.

1. Two parallel oppositely charged metal plates have an electric field between them. The magnitude is
- **(a)** greatest near the positive plate
- **(b)** greatest near the negative plate
- **(c)** zero
- **(d)** uniform throughout the region

2. The magnitude of the electric field at a point in space is equal to the
- **(a)** force a charge of 1 C would experience there
- **(b)** force a negative charge would experience there
- **(c)** force a positive charge would experience there
- **(d)** potential difference there
- **(e)** electric charge there

3. The force on a proton in an electric field of 100 N/C (1.0×10^2 N/C) is
- **(a)** 1.6×10^{-17} N
- **(b)** 1.6×10^{-19} N
- **(c)** 1.6×10^{-21} N
- **(d)** 6.2×10^{20} N

4. Magnetic fields do not interact with
- **(a)** stationary permanent magnets
- **(b)** moving permanent magnets
- **(c)** stationary electric charges
- **(d)** moving electric charges
- **(e)** none of the above

5. An electron moves horizontally to the east through a magnetic field that is downward. The force on the electron is toward the
- **(a)** N
- **(b)** S
- **(c)** E
- **(d)** W

6. A current is flowing west along a power line. Neglecting Earth's magnetic field, the direction of the magnetic field above it is
- **(a)** N
- **(b)** S
- **(c)** E
- **(d)** W

7. The electric and magnetic forces in a velocity selector are directed
- **(a)** at 90° to each other
- **(b)** parallel to each other, in the same direction
- **(c)** opposite to each other

Short Answer

8. Do electric field lines point in the direction of increasing or decreasing electric potential?

9. Why do electric field lines come out of positive charges and enter negative charges?

10. What similarities and differences are there between electric potential energy and gravitational potential energy?

11. In a 10 000 V power line, how many units of energy is carried by each unit of charge making up the current?

12. How is the principle of superposition used in problems of determining the field value due to multiple charges?

13. Explain why there is no parallel component to the electric field on the surface of conductors.

14. **(a)** The direction of motion of a positively charged particle, the direction of the magnetic field, and the direction of the magnetic force on the particle are mutually perpendicular. Draw a sketch of this situation and describe the right-hand rule that models the relationship among these directions.

(b) The direction of a current in a conductor, the direction of the magnetic field, and the direction of the force on the conductor are mutually perpendicular. Draw a sketch of this situation and describe the right-hand rule that models the relationship among these directions.

15. **(a)** Describe the characteristics of the force required to create and maintain circular motion at constant speed.

(b) Discuss examples that illustrate how each of the following fields can provide such a force on an object or charged particle and cause circular motion: gravitational field, electric field, and magnetic field.

16. Why is it more difficult to provide a simple equation for the strength of a magnetic force than it is for the strength of a gravitational force, the universal law of gravitation, or the strength of an electrostatic force, Coulomb's law?

17. Consider an electric field around an irregularly shaped, positively charged object. Draw a sketch of this situation by placing the charged object at the origin of a Cartesian coordinate system. Make labelled drawings to illustrate your written answers to the following questions.

(a) In which direction will the field push a small positive test charge?

(b) Where does the positive test charge have its greatest electric potential energy?

(c) In which direction will the field push a small negative charge?

(d) Where does the negative charge have the greatest magnitude of its electric potential energy?

18. (a) Describe the main features of coaxial cable.

(b) Explain why coaxial cables were designed to replace flat, twin-lead wire.

19. Explain whether it is possible to determine the charge and mass of a charged particle by separate electric or magnetic forces, that is, individually and not simultaneously.

Inquiry

20. Describe an experiment in which you could determine whether the charges on a proton and electron were the same in magnitude.

21. Devise an experiment that verifies Coulomb's law. Show that the electric force should be proportional to the product of the charges and show that the electric force should be proportional to the inverse square of the distance.

22. You place a neutral object between a pair of parallel charged plates. Will it experience a net force? Will it rotate?

23. The following table shows some results that Millikan obtained during his oil-drop experiment. In this trial, the distance over which the oil drop was measured (the distance between the cross hairs in the eyepiece) was always 1.0220 cm. The second column shows the time of travel under the action of gravity alone, and the third column shows the time for an oil drop to rise when the electric field was turned on.

(a) Calculate the velocity that corresponds to each trial.

(b) Group the common velocities.

(c) Analyze the velocities in a manner similar to Millikan's and show the evidence for a fundamental charge.

Trial	Fall (seconds)	Rise (seconds)
1	51.13	30.55
2	51.25	21.86
3	51.19	50.72
4	51.32	148.63
5	51.53	147.46
6	51.69	50.29
7	51.55	50.25
8	51.54	50.39
9	51.98	49.70
10	51.64	146.41

24. Two identical pith balls, mass 1.26 g, have a charge of +4.00 nC. One ball (A) is attached to the end of a light rod made of insulating material; the other (B) is suspended from a fixed point by an insulated thread 80.0 cm long. When ball A is held at various horizontal distances from B, the angle between the thread and the vertical is measured. Determine whether the results support Coulomb's law.

Horizontal distance between A and B (cm)	Angular displacement of thread
0.50	25.0°
1.00	6.65°
1.50	2.97°
1.80	2.06°
2.10	1.51°
2.50	1.07°

Communication

25. The two statements "like poles repel" and "unlike poles attract" are throwbacks to the action-at-a-distance theory, in that they imply the two poles interact with each other directly. Rewrite these two statements to reflect a field theory perspective.

26. Use the concepts of the electric field and electric field lines to convince someone that like charges should repel each other.

27. Explain how it would be possible to measure Coulomb's constant.

28. Contrast the concepts of potential difference and difference of potential energy.

29. Use Newton's law of universal gravitation to explain why Earth is round.

30. Determine the direction of the unknown vector for each of the following situations. Consider north as the top of the page and sketch the directions of the magnetic field lines, the direction of the charged particle and the force that acts on it.

- **(a)** an electron moving east, experiencing a force directed into the page
- **(b)** a proton moving north in a magnetic field directed west
- **(c)** an electron moving in a magnetic field directed into the page, experiencing a force to the south
- **(d)** a proton experiencing a force to the east, moving north
- **(e)** an electron, experiencing no force, moving in a magnetic field directed east
- **(f)** a proton experiencing a force to the south as it travels west

31. Describe the significance to twentieth-century physics of the Millikan oil-drop experiment.

32. Consider a stream of protons moving parallel to a stream of electrons. Is the electric force between the streams attractive or repulsive? Is the magnetic force between the streams attractive or repulsive? What factor(s) determine which force will dominate?

33. **(a)** Sketch the electric field between two parallel charged plates. Label the orientation of the charges on the plates. Show the trajectory of a positive charge sent into the field in a direction perpendicular to the field. In which direction is the electric force on the particle? Is work done on the particle as it passes between the plates?

(b) Sketch the magnetic field between the north pole of one magnet and the south pole of a different magnet. Both are set up in such a way that the field will be uniform. Show the trajectory of a positive charge sent into the field in a direction perpendicular to the field. In which direction is the magnetic force on the particle? Is work done on the particle as it passes through the field?

34. A current runs from west to east in a horizontal wire. If Earth's magnetic field points due north at this location, what is the direction of the force on the current?

35. Explain how a current balance can be used to measure the intensity of the magnetic field along the axis of a solenoid.

36. Explain how a velocity selector is able to filter a beam of particles of different velocities so that only particles with the same velocity continue in a mass spectrometer.

Making Connections

37. **(a)** Use science journals, your library, and/or the Internet to determine how auroras are formed.

(b) Discuss the phenomenon in terms of electric, gravitational, and magnetic fields.

(c) The photograph opening Chapter 8 shows the aurora borealis and the aurora australis occurring simultaneously. Explain whether you think this is a unique occurrence or one that will recur.

38. The torsion balance played an essential role in Coulomb's work. Research the history of the use of the torsion balance in physics. How is a torsion pendulum different?

39. Research and report on how the concept of the field has evolved. Discuss Faraday's and Maxwell's contributions. Also, discuss the role of Einstein's general theory of relativity in our present view of gravitational fields.

40. Albert Einstein spent the last several years of his life trying to devise a unified field theory that would show that gravity and the electric and magnetic forces were different aspects of the same phenomenon. He did not succeed. In the 1960s, it was shown that electric and magnetic forces and the weak nuclear force are different aspects of the same force: the unified electroweak force. To date, no one has linked gravity or the strong nuclear force with the unified electroweak force. Research the unification of forces and explain why the problem is so difficult to solve.

41. The Sun's magnetic field is responsible for sunspots, small regions on the surface of the Sun that are cooler and have a much higher magnetic field concentration than their surroundings. The Sun's magnetic field is also responsible for producing solar flares and other solar activity. Prepare a report that summarizes the latest research on the Sun's magnetic field and the types of solar phenomena that are being examined. Incorporate into your report the findings provided by the orbiting solar satellite, the Solar and Heliospheric Observatory (SOHO).

42. Research the principle behind the defibrilator and the steps that have been made to ensure its presence on all major aircraft.

43. Research the structure of an electrostatic air cleaner and discuss the function of the charging electrode and the grid.

44. In what way is electrostatic force used in the electroplating process in automobile manufacturing?

45. Research and explain the part played by the electric field in
- (a) the xerographic process
- (b) laser printers
- (c) inkjet printers

46. Prepare a cost-benefit analysis of the use of the electric car.

47. "Electron guns" are used in television sets to propel electrons toward the screen. What techniques are then used to deflect the electron beam and "paint" a picture?

48. Discuss the role of electric potential difference in the following medical diagnostic techniques.
- (a) electroencephalography
- (b) electroretinography

Problems for Understanding

49. What is the total charge on 1.0 g of electrons?

50. What is the magnitude of the electric force between a proton and electron in a hydrogen atom if they are 52.9 pm apart?

51. A nucleus of argon has a charge of +18 e and a nucleus of krypton has a charge of +36 e, where e is the elementary charge, 1.60×10^{-19} C. If they are 8.0 nm apart, what force does one exert on the other?

52. Two small ball bearings sit 0.75 m apart on a table and carry identical charges. If each ball bearing experiences a force of 3.0 N, how large is the charge on each?

53. How many electrons must be removed from an isolated conducting sphere 12 cm in diameter to produce an electric field of intensity 1.5×10^{-3} N/C just outside its surface?

54. Two identical charges exert a force of 50.0 N[repulsion] on each other. Calculate the new force if

(a) one of the charges is changed to the exact opposite
(b) instead, the distance between the charges is tripled
(c) instead, one charge is doubled in magnitude and the other is reduced to one third of its magnitude
(d) all of the above changes are made

55. Two identical pith balls, each with a mass of 0.50 g, carry identical charges and are suspended from the same point by two threads of the same length, 25.0 cm. In their equilibrium position, the angle between the two threads at their suspension point is 60°. What are the charges on the balls?

56. Suppose you wanted to replace the gravitational force that holds the Moon in orbit around Earth by an equivalent electric force. Let the Moon have a net negative charge of $-q$ and Earth have a net positive charge of $+10\ q$. What value of q do you require to give the same magnitude force as gravity?

57. Earth carries a net charge of -4.3×10^5 C. When the force due to this charge acts on objects above Earth's surface, it behaves as though the charge was located at Earth's centre. How much charge would you have to place on a 1.0 g mass in order for the electric and gravitational forces on it to balance?

58. Suppose you want to bring two protons close enough together that the electric force between them will equal the weight of either at Earth's surface. How close must they be?

59. Calculate the repulsive force between two 60 kg people, 1.0 m apart, if each person were to have 1% more electrons than protons. (Assume for simplicity that a neutral human body has equal numbers of protons and neutrons.)

60. What will be the net force, considering both gravitational and electrostatic forces, between a deuterium ion and a tritium ion placed 5.0 cm apart?

61. What must be the charge on a pith ball of mass 3.2 g for it to remain suspended in space when placed in an electric field of 2.8×10^3 N/C[up]?

62. (a) Calculate the repulsive Coulomb force between two protons separated by 5×10^{-15} m in an atomic nucleus.
(b) How is it possible that such a force does not cause the nucleus to fly apart?

63. The electric potential difference between two large, charged parallel plates is 50 V. The plates are 2.5 cm apart. What is the electric field between them?

64. How many electrons make up a charge of 1.0 μC?

65. A 2.0 pC charge is located at point A on an imaginary spherical surface which is centred on a 4.0 μC point charge 2.8 cm away. How much work is required to move the 2.0 pC charge to the following two points?
(a) to point B, which is located on the same spherical surface an arc length 3.0 cm away
(b) to point C, which is located radially outward from A on another imaginary spherical surface of radius 4.2 cm
(c) What name could be used to describe these spherical surfaces?

66. Two horizontal plates used in an oil-drop experiment are 12 mm apart, with the upper plate being negative. An oil drop, with a mass of 6.53×10^{-14} kg, is suspended between the plates. The electric potential difference is 1.6×10^4 V. Calculate the
(a) total charge on the oil drop
(b) number of excess or deficit electrons on the oil drop
(c) electric potential difference required to suspend the oil drop if an electron is knocked off it by an X ray

67. A current of 2.0 A runs through a wire segment of 3.5 cm. If the wire is perpendicular to a uniform magnetic field and feels a magnetic force of 7.0×10^{-3} N, what is the magnitude of the magnetic field?

68. A small body of unknown charge, travelling 6.1×10^5 m/s, enters a 0.40 T magnetic field directed perpendicular to its motion.
(a) If the particle experiences a force of 9.0×10^{-4} N, what is the magnitude of the charge?

(b) If the object is sent into the magnetic field so that its velocity makes an angle of 30.0° with the magnetic field, by how much will the magnetic force be reduced?

69. Consider a proton that is travelling northward with a velocity of 5.8×10^6 m/s in a particle accelerator. It enters an east-directed magnetic field of 0.25 T.
(a) Calculate the magnetic force acting on the proton.
(b) What is the magnitude and direction of its acceleration?

70. A proton travelling at 2×10^7 m/s horizontally enters a magnetic field of strength 2.4×10^{-1} T, which is directed vertically downward. Calculate the consequent radius of orbit of the proton.

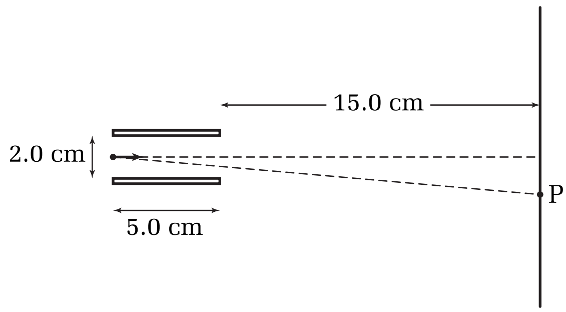
71. Prove that the radius of orbit of a particle in a mass spectrometer is equal to p/qB, where p is its momentum.

72. (a) An electron is fired into a 0.20 T magnetic field at right angles to the field. What will be its period if it goes into a circular orbit?
(b) If the electron is moving at 1.0×10^7 m/s, what is the radius of its orbit?

73. You want to create a beam of charged particles that have a speed of 1.5×10^6 m/s. You use a crossed electric and magnetic field and choose a magnet with a strength of 2.2×10^{-4} T. What must be the magnitude of the electric field?

74. A charged particle that is sent into a magnetic field at an angle will follow a helical path, the characteristics of which can be calculated from the particle's velocity parallel and perpendicular to the field. Consider a magnetic field of strength 0.26 T directed toward the east. A proton with a speed of 6.5×10^6 m/s is shot into the magnetic field in the direction [E30.0°N].
(a) Calculate the proton's velocity in the directions parallel and perpendicular to the magnetic field.
(b) Calculate the radius of the proton's orbit as it spirals around the magnetic field. (Hint: Which component of the velocity contributes to this motion?)
(c) How long will it take the proton to complete a singular circular orbit?
(d) During the time that it takes the proton to complete one orbit, how far will the proton travel toward the east? (Hint: Which component of the proton's velocity contributes to this motion?)
(e) Sketch the proton's path as seen from the side and as seen looking west into the magnetic field.

75. The diagram shows an electron entering the region between the plates of a cathode ray tube (the basic structure of a television tube). The electron has an initial velocity of 2.7×10^7 m/s horizontally and enters at the exact mid-axis of the plates. The electric field intensity between the plates is 2.80×10^4 N/C upward. How far below the axis of the plates will the electron strike the screen at point P?



COURSE CHALLENGE

Scanning Technologies: Today and Tomorrow

Plan for your end-of-course project by considering the following.

- Are you able to incorporate electric, gravitational, and magnetic fields into your analysis?
- Consider time and equipment requirements that might arise as you design project-related investigations.
- Examine the information that you have gathered to this point. Produce a detailed plan, including a time line, to guide you as you continue gathering information.